

CLAIMS

1. A magnetic random access memory comprising:
 - a plurality of first signal lines provided to extend in a first direction;
 - 5 a plurality of second signal lines provided to extend in a second direction substantially perpendicular to said first direction;
 - a plurality of memory cells respectively provided at intersections of said plurality of first
 - 10 signal lines and said plurality of second signal lines; and
 - a plurality of magnetic structures respectively provided for said plurality of memory cells,
 - 15 wherein each of said plurality of memory cells comprises a magneto-resistance element containing a spontaneous magnetization layer which has a first threshold function, and a direction of a spontaneous magnetization of said spontaneous
 - 20 magnetization layer is reversible when an element applied magnetic field equal to or larger than a value of the first threshold function is applied,
 - each of said plurality of magnetic structures has a second threshold function, and generates a
 - 25 magnetic structure magnetic field in response to a structure applied magnetic field, and generates a third magnetic field as said magnetic structure

magnetic field when said structure applied magnetic field is equal to or larger than a value of a second threshold function, and a fourth magnetic field, which is weaker than said third magnetic field, as said
5 magnetic structure magnetic field, when said structure applied magnetic field is less than the second threshold function value,

a first write current is supplied to one of said plurality of first signal lines as a first
10 selected signal line such that a first magnetic field is generated, a second write current is supplied to one of said plurality of second signal lines as a second selected signal line such that a second magnetic field is generated, and a first synthetic
15 magnetic field of said first magnetic field and said second magnetic field is applied to said plurality of magnetic structures as said structure applied magnetic field, and

a second synthetic magnetic field of said
20 first synthetic magnetic field and said magnetic structure magnetic field is generated as said element applied magnetic field such that said element applied magnetic field equal to or larger than the first threshold function value is applied to a selected
25 memory cell provided at the intersection of said first selected signal line and said second selected signal line, and such that said element applied magnetic

field less than the first threshold function value is applied to each of non-selected memory cells as ones said plurality of memory cells other than said selected memory cell.

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2. The magnetic random access memory according to claim 1, wherein each of said plurality of magnetic structures comprises:

a first magnetic layer formed of
10 ferromagnetic material;

a second magnetic layer formed of
ferromagnetic material; and

a non-magnetic layer interposed between said
first magnetic layer and said second magnetic layer.

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3. The magnetic random access memory according to claim 1, wherein said non-magnetic layer has a film thickness such that said first magnetic layer is anti-ferromagnetically coupled to said second magnetic

20 layer.

4. The magnetic random access memory according to claim 2 or 3, wherein the second threshold function is determined based on the film thickness of said non-

25 magnetic layer.

5. The magnetic random access memory according

to any of claims 2 to 4, wherein when said structure applied magnetic field is not applied, said magnetic structure magnetic field generated by said magnetic structure is substantially 0.

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6. The magnetic random access memory according to any of claims 1 to 5, wherein said first synthetic magnetic field larger than the second threshold function value is applied as said structure applied

10 magnetic field to said magnetic structure

corresponding to said selected memory cell, said magnetic structure corresponding to said selected memory cell generates said third magnetic field as said magnetic structure magnetic field, said synthetic

15 magnetic field of said first synthetic magnetic field

and said third magnetic field is applied to said magneto-resistance element of said selected memory cell as said element applied magnetic field equal to or larger than the first threshold function value, and

20 said first synthetic magnetic field having

the intensity less than the second threshold function value is applied as said structure applied magnetic field to said magnetic structure corresponding to each of said non-selected memory cells, said magnetic

25 structure corresponding to said non-selected memory

cell generates said fourth magnetic field as the magnetic structure magnetic field, and said synthetic

magnetic field of said first synthetic magnetic field and said fourth magnetic field is applied to said magneto-resistance element of said selected memory cell as said element applied magnetic field less than
5 the first threshold function value.

7. The magnetic random access memory according to any of claims 1 to 5, wherein said first synthetic magnetic field less than the second threshold function
10 value is applied as said structure applied magnetic field to said magnetic structure corresponding to said selected memory cell, said magnetic structure corresponding to said selected memory cell generates said fourth magnetic field as said magnetic structure
15 magnetic field, and said synthetic magnetic field of said first synthetic magnetic field and said fourth magnetic field is applied to said magneto-resistance element of said selected memory cell as said element applied magnetic field equal to or larger than the
20 first threshold function value, and

said first synthetic magnetic field having the intensity equal to or larger than the second threshold function value is applied as said structure applied magnetic field to said magnetic structure
25 corresponding to each of said non-selected memory cells, said magnetic structure corresponding to said non-selected memory cell generates said third magnetic

field as said magnetic structure magnetic field, and
said synthetic magnetic field of said first synthetic
magnetic field and said third magnetic field is
applied to said magneto-resistance element of said
5 selected memory cell as said element applied magnetic
field less than the first threshold function value.

8. The magnetic random access memory according
to claim 6, wherein one of said plurality of first
10 signal lines and one of said plurality of second
signal lines are provided between a corresponding one
of said plurality of memory cells and said magnetic
structure corresponding to the corresponding memory
cell, and
15 said corresponding magnetic structure is
provided directly or indirectly on said first signal
line.

9. The magnetic random access memory according
20 to claim 7, wherein each of said plurality of memory
cells and said magnetic structure corresponding to
said memory cell are provided between one of said
plurality of first signal lines corresponding to said
memory cell and one of said plurality of second signal
25 lines corresponding to said memory cell.

10. The magnetic random access memory according

to claim 6 or 8, wherein said magnetic structure has a circular plane structure.

11. The magnetic random access memory according
5 to any of claims 6 to 9, wherein said magnetic structure has an elliptical plane structure.

12. The magnetic random access memory according
to claim 11, wherein an elliptical long axis of said
10 magnetic structure is directed into a direction other than the first direction and the second direction.

13. The magnetic random access memory according
to claim 12, wherein the elliptical long axis of said
15 magnetic structure is directed to the direction of 45 degrees from each of the first direction and the second direction.

14. A magnetic random access memory comprising:
20 a plurality of first signal lines provided to extend in a first direction;

 a plurality of second signal lines provided
to extend in a second direction substantially
perpendicular to the first direction;

25 a plurality of memory cells, each of which contains a magneto-resistance element having a spontaneous magnetization whose direction is

reversible based on data to be stored, and which are respectively provided at intersections of said plurality of first signal lines and said plurality of second signal lines; and

5 a plurality of magnetic structures which are provided for said plurality of memory cells, and each of which applies a magnetic field to said magneto-resistance element contained in a corresponding one of said plurality of memory cells based on induced
10 magnetization,

 wherein one of said plurality of memory cells provided for the intersection of a first selected signal line selected from among said plurality of first signal lines and a second selected signal line
15 from among said plurality of second signal lines is a selected memory cell,

 one of said plurality of magnetic structures corresponding to said selected memory cell is a selected magnetic structure,

20 one of said plurality of memory cells which is other than said selected memory cell and which intersects said first selected signal line is a first non-selected memory cell,

 one of said plurality of magnetic structures
25 corresponding to said first non-selected memory cell is a first non-selected magnetic structure,

 a synthetic magnetic field H_{xy} applied to said

selected magnetic structure by a first write current flowing through said first selected signal line in a write operation and a second write current flowing through said second selected signal line in the write
5 operation, said magnetization M_{xy} induced in said selected magnetic structure by said synthetic magnetic field H_{xy} , a magnetic field H_y applied to each of said first non-selected magnetic structures by said first write current in the write operation, and a
10 magnetization M_y induced in said first non-selected magnetic structure by said magnetic field H_y satisfy the following relation:

$$M_{xy}/H_{xy} \neq M_y/H_y.$$

15 15. The magnetic random access memory according to claim 14, wherein one of said plurality of memory cells which is other than said selected memory cell and which intersects said second selected signal line is a second non-selected memory cell, and

20 one of said plurality of magnetic structures corresponding to said second non-selected memory cell is a second non-selected magnetic structure,

said synthetic magnetic field H_{xy} , said magnetization M_{xy} , a magnetic field H_x applied to said
25 second non-selected magnetic structure by said second write current in the write operation, and a magnetization M_x induced in said second non-selected

magnetic structure by said magnetic field H_x satisfy the following relation:

$$M_{xy}/H_{xy} \neq M_x/H_x.$$

5 16. The magnetic random access memory according to claim 14, wherein said plurality of magnetic structures are arranged in positions where said magnetization M_{xy} and said magnetization M_y are induced such that a magnetic field applied to said magneto-
10 resistance element contained in said selected memory cell by said first write current and said second write current and a magnetic field applied to said magneto-resistance element contained in said first non-selected memory cell by said first write current are
15 enhanced, and

said magnetic field H_y , said synthetic magnetic field H_{xy} , said magnetization M_y and said magnetization M_{xy} satisfy

$$M_{xy}/H_{xy} > M_y/H_y.$$

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17. The magnetic random access memory according to claim 14, wherein said plurality of first signal lines and said plurality of second signal lines are located between said plurality of magnetic structures
25 and said plurality of memory cells, and

said magnetic field H_y , said synthetic magnetic field H_{xy} , said magnetization M_y and said

magnetization M_{xy} satisfy

$$M_{xy}/H_{xy} > M_y/H_y.$$

18. The magnetic random access memory according
5 to claim 17, wherein one of said plurality of memory
cells which is other than said selected memory cell
and which intersects said second selected signal line
is a second non-selected memory cell,

one of said plurality of magnetic structures
10 corresponding to said second non-selected memory cell
is a second non-selected magnetic structure, and

said synthetic magnetic field H_{xy} , said
magnetization M_{xy} , said magnetic field H_x applied to
said second non-selected magnetic structure by said
15 second write current in the write operation, and said
magnetization M_x induced in said second non-selected
magnetic structure by said magnetic field H_x satisfy
 $M_{xy}/H_{xy} > M_x/H_x$.

20 19. The magnetic random access memory according
to claim 14, wherein said plurality of magnetic
structures are arranged in positions where said
magnetization M_{xy} and said magnetization M_y are induced
such that a magnetic field applied to said magneto-
25 resistance element contained in said selected memory
cell by said first write current and said second write
current and a magnetic field applied to said magneto-

resistance element contained in said first non-selected memory cell by said first write current are weakened, and

5 said magnetic field H_y , said synthetic magnetic field H_{xy} , said magnetization M_y , and said magnetization M_{xy} satisfy
 $M_{xy}/H_{xy} < M_y/H_y$.

20. The magnetic random access memory according
10 to claim 14, wherein said plurality of magnetic structures and said plurality of memory cells are located between said plurality of first signal lines and said plurality of second signal lines, and

 said magnetic field H_y , said synthetic
15 magnetic field H_{xy} , said magnetization M_y and said magnetization M_{xy} satisfy
 $M_{xy}/H_{xy} < M_y/H_y$.

21. The magnetic random access memory according
20 to claim 20, wherein one of said plurality of memory cells which is other than said selected memory cell and which intersects said second selected signal line is a second non-selected memory cell,

 one of said plurality of magnetic structures
25 corresponding to said second non-selected memory cell is a second non-selected magnetic structure, and
 said synthetic magnetic field H_{xy} , said

magnetization M_{xy} , said magnetic field H_x applied to
said second non-selected magnetic structure by said
second write current in the write operation, and said
magnetization M_x induced in said second non-selected
5 magnetic structure satisfy
 $M_{xy}/H_{xy} < M_x/H_x$.

22. The magnetic random access memory according
to any of claims 14 to 21, wherein each of said
10 plurality of magnetic structures comprises a ferri-
magnetic laminate structure comprises:

a first magnetic layer formed of
ferromagnetic material;
a second magnetic layer formed of
15 ferromagnetic material; and
a non-magnetic layer interposed between said
first magnetic layer and said second magnetic layer
and having a film thickness such that said first
magnetic layer is anti-ferromagnetically coupled to
20 said second magnetic layer.

23. The magnetic random access memory according
to claim 16 or 17, wherein each of said plurality of
magnetic structures comprises a ferri-magnetic
25 laminate structure comprises:

a first magnetic layer formed of
ferromagnetic material;

a second magnetic layer formed of
ferromagnetic material; and

a non-magnetic layer interposed between said
first magnetic layer and said second magnetic layer,
5 and having a film thickness such that said first
magnetic layer is anti-ferromagnetically coupled to
said second magnetic layer,

said synthetic magnetic field H_{xy} is larger
than a threshold magnetic field H_{txy} of said ferri-
10 magnetic laminate structure in a direction of said
synthetic magnetic field H_{xy} , and

said magnetic field H_y is smaller than a
threshold magnetic field H_{ty} of said ferri-magnetic
laminate structure in a direction of a magnetic field
15 H_y .

24. The magnetic random access memory according
to claim 18, wherein each of said plurality of
magnetic structures comprises a ferri-magnetic
20 laminate structure comprises:

a first magnetic layer formed of
ferromagnetic material;

a second magnetic layer formed of
ferromagnetic material; and

25 a non-magnetic layer interposed between said
first magnetic layer and said second magnetic layer
and having a film thickness such that said first

magnetic layer is anti-ferromagnetically coupled to said second magnetic layer,

said synthetic magnetic field H_{xy} is larger than a threshold magnetic field H_{txy} of said ferri-magnetic laminate structure in a direction of said synthetic magnetic field H_{xy} ,

said magnetic field H_x is smaller than a threshold magnetic field H_{tx} of said ferri-magnetic laminate structure in a direction of said magnetic field H_x , and

said a magnetic field H_y is smaller than a threshold magnetic field H_{ty} of said ferri-magnetic laminate structure in a direction of said magnetic field H_y .

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25. The magnetic random access memory according to claim 24, wherein anisotropy is given to said magneto-resistance element such that the direction of said spontaneous magnetization of said magneto-

resistance element is substantially coincident with the first direction, and to said ferri-magnetic laminate structure such that directions of spontaneous magnetizations of said first magnetic layer and said second magnetic layer are directed into a third direction which is not perpendicular to the first direction.

26. The magnetic random access memory according to claim 24, wherein an angle between the first direction and the third direction is substantially 45 degrees.

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27. The magnetic random access memory according to claim 25, wherein the direction of said synthetic magnetic field H_{xy} is substantially perpendicular to the third direction.

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28. The magnetic random access memory according to claim 19 or 20, wherein each of said plurality of magnetic structures comprises a ferri-magnetic laminate structure comprises:

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a first magnetic layer formed of ferromagnetic material;

a second magnetic layer formed of ferromagnetic material; and

a non-magnetic layer interposed between said first magnetic layer and said second magnetic layer and having a film thickness such that said first magnetic layer is anti-ferromagnetically coupled to said second magnetic layer,

said synthetic magnetic field H_{xy} is smaller than a threshold magnetic field $H_{t_{xy}}$ of said ferri-magnetic laminate structure in a direction of said synthetic magnetic field H_{xy} , and

said magnetic field H_y is larger than a threshold magnetic field H_{ty} of said ferri-magnetic laminate structure in a direction of the magnetic field H_y .

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29. The magnetic random access memory according to claim 28, wherein anisotropy is given to said magneto-resistance element such that the direction of the spontaneous magnetization of said magneto-
10 resistance element is substantially coincident with the first direction, and to said ferri-magnetic laminate structure such that directions of spontaneous magnetizations of said first magnetic layer and said second magnetic layer are substantially coincident
15 with the first direction.

30. The magnetic random access memory according to claim 21, wherein each of said plurality of magnetic structures comprises a ferri-magnetic
20 laminate structure comprises:

a first magnetic layer formed of ferromagnetic material;

a second magnetic layer formed of ferromagnetic material; and

25 a non-magnetic layer interposed between said first magnetic layer and said second magnetic layer and having a film thickness such that said first

magnetic layer is anti-ferromagnetically coupled to said second magnetic layer,

said synthetic magnetic field H_{xy} is smaller than a threshold magnetic field H_{txy} of said ferri-magnetic laminate structure in a direction of said synthetic magnetic field H_{xy} ,

said magnetic field H_x is larger than a threshold magnetic field H_{tx} of said ferri-magnetic laminate structure in a direction of said magnetic field H_x and

said magnetic field H_y is larger than a threshold magnetic field H_{ty} of said ferri-magnetic laminate structure in a direction of said magnetic field H_y .

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31. The magnetic random access memory according to claim 30, wherein anisotropy is given to said magneto-resistance element such that a direction of the spontaneous magnetization of said magneto-resistance element is substantially coincident with the first direction, and to said ferri-magnetic laminate structure such that directions of spontaneous magnetizations of said first magnetic layer and said second magnetic layer are directed into a third direction which is not perpendicular to the first direction.

32. The magnetic random access memory according to claim 21, wherein the direction of said synthetic magnetic field H_{xy} is substantially identical to the third direction.

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